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Radioactivity in the Risø District January-June 2018

DTU Nutech Report

Sven P. Nielsen, Kasper G. Andersson and Arne Miller
DTU-Nutech-18(EN)
December 2018

DTU Nutech
Center for Nuclear Technologies

Author: Jixin Qiao, Kasper G. Andersson and Arne Miller
Title: Radioactivity in the Risø District January-June 2018
Center for Nuclear Technologies

DTU-Nutech-18(EN)
December 2018

Abstract (max. 2000 char.): The environmental surveillance of the Risø environment was continued in January-June 2018.
The mean concentrations in air were: 0.37±0.27 μBq m^{-3} of ^{137}Cs, 4.00±1.59 mBq m^{-3} of ^{7}Be and 0.37±0.26 mBq m^{-3} of ^{210}Pb (±1 S.D.). The depositions by precipitation at Risø in the first half of 2018 were: 0.045±0.007 Bq m^{-2} of ^{137}Cs, 316±32 Bq m^{-2} of ^{7}Be, 28.4±2.6 Bq m^{-2} of ^{210}Pb and <0.9 kBq m^{-2} of ^{3}H. The average background dose rate (TLD) at Risø (Zone I) was measured as 59 nSv h^{-1} compared with 55 ± 3 nSv h^{-1} (±1 S.D.) in the four zones around Risø.

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INTRODUCTION

A specific monitoring programme in the vicinity of the nuclear installations at the Risø site is carried out by DTU Nutech on behalf of and as a contractor to Danish Decommissioning (DD). This report presents the analytical results of the monitoring and sampling carried out in the period January-June 2018. The materials and methods used in connection with the monitoring programme are described in pages 23-24.

Table 1. Radionuclides in ground level air collected at Risø (cf. Figs. 1, 1.1 and 1.2), January - June 2018 (Unit: μBq m^{-3})

Date			^{7}Be	^{137}Cs	^{210}Pb
03-Jan-18	–	08-Jan-18	1681(10%)*	0.379(11%)	143(10%)
08-Jan-18	–	15-Jan-18	4177(10%)	0.546(10%)	265(10%)
15-Jan-18	–	22-Jan-18	2170(10%)	0.284(11%)	128(10%)
22-Jan-18	–	29-Jan-18	4279(10%)	0.230(10%)	137(10%)
29-Jan-18	–	05-Feb-18	4280(10%)	0.244(12%)	318(10%)
05-Feb-18	–	12-Feb-18	4134(10%)	0.426(11%)	730(10%)
12-Feb-18	–	19-Feb-18	2155(10%)	0.260(10%)	139(10%)
19-Feb-18	–	26-Feb-18	2334(10%)	0.393(11%)	463(10%)
26-Feb-18	–	05-Mar-18	3407(10%)	0.407(11%)	1059(10%)
05-Mar-18	–	12-Mar-18	2867(10%)	1.416(10%)[a]	1068(10%)
12-Mar-18	–	19-Mar-18	3057(10%)	0.547(10%)	465(10%)
19-Mar-18	–	26-Mar-18	2716(10%)	0.349(11%)	175(10%)
26-Mar-18	–	03-Apr-18	5465(10%)	0.687(10%)	424(10%)
03-Apr-18	–	09-Apr-18	5357(10%)	0.305(10%)	276(10%)
09-Apr-18	–	16-Apr-18	4129(10%)	0.680(10%)	416(10%)
16-Apr-18	–	23-Apr-18	4661(10%)	0.246(11%)	387(10%)
23-Apr-18	–	30-Apr-18	3150(10%)	0.156(12%)	192(10%)
30-Apr-18	–	07-May-18	5244(10%)	0.222(11%)	328(10%)
07-May-18	–	15-May-18	7108(10%)	0.473(10%)	469(10%)
15-May-18	–	22-May-18	6761(10%)	0.345(11%)	418(10%)
22-May-18	–	29-May-18	6334(10%)	0.248(12%)	404(10%)
29-May-18	–	04-Jun-18	6169(10%)	0.442(11%)	505(10%)
04-Jun-18	–	11-Jun-18	5091(10%)	0.116(11%)	261(10%)
11-Jun-18	–	18-Jun-18	2851(10%)	0.046(15%)	140(10%)
18-Jun-18	–	25-Jun-18	1749(10%)	0.155(11%)	82(10%)
25-Jun-18	–	02-Jul-18	2544(10%)	0.110(13%)	248(10%)
Mean			3995	0.373	371
SD			1589	0.269	255

∗Figures in brackets are relative standard uncertainties

[a] Increased concentrations possibly caused by forest fires in areas of Eastern Europe contaminated from the Chernobyl accident. Increased values also recorded at this time by FOI, Sweden, in Gotland.

Table 2.1. Radionuclides in precipitation in the 10 m^2 rain collector at Risø (cf. Fig. 8.1), January - June 2018. (Unit: Bq m^{-3})

Month	^{7}Be	^{137}Cs	^{210}Pb
January	1709(10%)*	0.072(19%)	93(11%)
February	1882(10%)	0.767(32%)	274(10%)
March	1263(10%)	0.121(16%)	140(10%)
April	1500(10%)	0.227(17%)	168(10%)
May	3864(10%)	0.695(18%)	292(10%)
June	6803(10%)	1.385(24%)[a]	936(11%)

*Figures in brackets are relative standard uncertainties

[a]Note: Enhanced concentration due to low precipitation in this month, see Table 2.2.

Table 2.2. Radionuclides in precipitation in the 10 m^2 rain collector at Risø (cf. Fig. 8.1), January - June 2018. (Unit: Bq m^{-2})

Month	Precipitation (m)	^{7}Be	^{137}Cs	^{210}Pb
January	0.039(10%)*	67.2(14%)	0.0028(21%)	3.7(15%)
February	0.009(10%)	16.8(14%)	0.0068(34%)	2.4(14%)
March	0.054(10%)	68.6(14%)	0.0065(19%)	7.6(14%)
April	0.018(10%)	27.3(14%)	0.0041(20%)	3.1(14%)
May	0.030(10%)	116(14%)	0.0209(21%)	8.8(14%)
June	0.003 (10%)	20.5(14%)	0.0042(26%)	2.8(15%)
Sum	0.153(5%)	316.4(10%)	0.0453(15%)	28.4(9%)

*Figures in brackets are relative standard uncertainties

Table 2.3. Tritium in precipitation collected at Risø (cf. Figs. 1, 2.3.1 and 2.3.2). January - June 2018. (Unit: kBq m^{-3})

Month	10 m^2 rain collector*
January	3.1(79%)[a]
February	4.9(19%)
March	10.0(7%)
April	< 3.0
May	< 3.0
June	< 3.0
Double determinations*.	

[a] Figures in brackets are relative standard uncertainties

Table 2.4. Tritium in precipitation collected at Risø (cf. Fig. 1). January - June 2018. (Unit: kBq m^{-2})

Month	Precipitation (m)	10 m^2 rain collector
January	0.039(10%)*	0.121(80%)
February	0.009(10%)	0.045(21%)
March	0.054(10%)	0.540(12%)
April	0.018(10%)	< 0.054
May	0.030(10%)	< 0.090
June	0.003 (10%)	< 0.009
Sum	0.153(5%)	< 0.859

[a] Figures in brackets are relative standard uncertainties

Table 3.1. Radionuclides in sediment samples collected at Bolund in Roskilde Fjord.(cf. Fig. 3.1) January - June 2018. (Unit: Bq kg^{-1} dry)

No samples in this period.

Table 4.1. Radionuclides in seawater collected in Roskilde Fjord (cf. Fig. 4.1) January - June 2018. (Unit: Bq m^{-3})

No samples in this period.

Table 4.2. Tritium in seawater collected in Roskilde Fjord (Risø pier) (cf. Fig. 4.2) January - June 2018.

Month	kBq m^{-3}
March	< 3.0 *
June	< 3.0

* Double determinations

Table 5.1. Radionuclides in grass (snow) collected at Risø near the Waste Treatment Station, location I P3, Fig. 1, January - June 2018. (**Measured on bulked ash samples)*

Week no. or month	Date	K (g kg^{-1} fresh)	^{137}Cs (Bq kg^{-1} fresh)	^{137}Cs (Bq m^{-2})
1	2 January	4.6(11%)[a]	<0.5	
3	15 January	8.0(10%)	<1.2	
5	29 January	1.3(10%)	<0.2	
7	12 February	0.3(11%)	<0.4	
9	26 February	5.5(12%)	<1.8	
11	13 March	0.8(11%)	<0.5	
13	26 March	1.9(11%)	<0.6	
15	9 April	6.3(10%)	<1.4	
17	23 April	6.7(10%)	<0.6	
19	7 May	7.5(10%)	<1.4	
21	22 May	6.0(10%)	<0.5	
23	4 June	7.2(10%)	<0.3	
25	18 June	7.5(10%)	<0.7	
**January		0.3(10%)	0.141(14%)	0.049(16%)
**February		0.3(10%)	0.122(28%)	0.022(31%)
**March		1.4(10%)	0.090(26%)	0.025(28%)
**April		0.1(10%)	0.085(45%)	0.020(48%)
**May		0.1(10%)	0.508(7%)	0.012(12%)
**June		0.1(10%)	0.068(7%)	0.036(12%)

[a] Figures in brackets are relative standard uncertainties

Table 5.2. Radionuclides in Fucus vesiculosus collected at Bolund in Roskilde Fjord. January - June 2018. (Unit: Bq kg^{-1} dry)

No samples in this period.

Table 7.1. Waste water collected at Risø (cf. Fig. 1), January - June 2018.

Week number	eqv. mg KCl l^{-1}	^{137}Cs (Bq m^{-3})	^{131}I (Bq m^{-3})	^{226}Ra (Bq m^{-3})
1	52(12%)*	<71	<79	<156
2	35(12)	<124	<125	<260
3	43(11)	<84.8	<80.3	<179
4	49(12)	<80.3	<81.3	<176
5	50(13)	<114	<122	<241
6	46(12)	<120	<124	<258
7	52(11)	<131	<136	<291
8	55(10)	<143	<147	<304
9	66(11)	<120	<119	<245
10	68(11)	<130	<133	<260
11	48(12)	<114	<131	<260
12	32(12)	<119	<132	<262
13	46(12)	<131	<139	<299
14	56(10)	<115	<125	<239
15	64(11)	<127	<129	<285
16	82(10)	<125	<131	<266
17	83(10)	<121	<129	<271
18	86(11)	<138	<147	<305
19	69(11)	<139	<139	<292
20	97(11)	<124	<135	<271
21	92(11)	<121	<125	<252
22	90(10)	<118	<126	<260
23	97(10)	<85	<94	<187
24	85(10)	<120	<117	<247
25	138(10)[a]	<128	<126	<263
26	62(11)	<114	<117	<246
Mean	67.0	<118	<123	<253
SD	24.2			

* Figures in brackets are relative standard uncertainties
[a] Enhanced value, but does not exceed the reporting threshold of 200 mg KCl/l agreed with DD.

Table 8.1. Background dose rates around the border of Risø (cf. Fig. 8.1) measured with thermoluminescence dosimeters (TLD) in the period November 2017 – April 2018. (Results are normalized to nSv h^{-1})

Location	nSv h^{-1} ¤
1	53(10%)[a]
2	53(10%)
3	70(10%)
4	57(10%)
5	62(10%)
6	69(10%)
Mean	61(5%)

[a] Figures in brackets in Table 8.1 and 8.2 are relative standard uncertainties

Table 8.2. Background dose rates around Risø (cf. Fig. 8.2 and Fig. 1) measured with thermoluminescence dosimeters (TLD) in the period November 2017– April 2018. (Results are normalized to nSv h^{-1}),

Risø zone	Location	nSv h^{-1} ¤
I	1	52(10%)[a]
I	2	62(10%)
I	3	85(10%)
I	4	63(10%)
I	5	68(10%)
Mean		66(5%)
II	P1	60(10%)
II	P2	63(10%)
II	P3	47(10%)
II	P4	47(10%)
Mean		54 (10%)
III	P1	54(10%)
III	P2	59(10%)
III	P3	50(10%)
Mean		54(6%)
IV	P1	43(10%)
IV	P2	47(10%)
IV	P3	57(10%)
IV	P4	54(10%)
IV	P5	56(10%)
IV	P6	50(10%)
IV	P7	64(10%)
Mean		53(4%)
V	P1	63(10%)
V	P2	56(10%)
V	P3	63(10%)
V	P4	51(10%)
V	P5	60(10%)
V	P6	Dosimeter lost
V	P7	52(10%)
V	P8	63(10%)
V	P9	53(10%)
V	P10	64(10%)
Mean		58(4%)

Table 8.3. Terrestrial dose rates at the Risø zones (cf. Fig. 8.2 and Fig. 1) January – June 2018. Measured with a NaI(Tl) detector. (Unit: nSv h^{-1})

Risø zone	Location	October
I	P1	43(10%)[a]
I	P2	54(10%)
I	P3	333(10%)
I	P4	39(10%)
I	P5	51(10%)
Mean		104(5%)
II	P1	48(10%)
II	P2	51(10%)
II	P3	42(10%)
II	P4	42(10%)
Mean		46(4%)
III	P1	49(10%)
III	P2	53(10%)
III	P3	45(10%)
Mean		49(6%)
IV	P1	39(10%)
IV	P2	50(10%)
IV	P3	47(10%)
IV	P4	44(10%)
IV	P5	35(10%)
IV	P6	45(10%)
IV	P7	50(10%)
Mean		45(4%)
V	P1	59(10%)
V	P2	56(10%)
V	P3	58(10%)
V	P4	50(10%)
V	P5	51(10%)
V	P6	45(10%)
V	P7	44(10%)
V	P7a	47(10%)
V	P8	48(10%)
V	P9	57(10%)
V	P10	41(10%)
Mean		50(4%)

[a] Figures in brackets are relative standard uncertainties

Fig. 1. Locations for measurements of gamma-background radiation Zone I and II (cf. Tables 8.2 and 8.3)

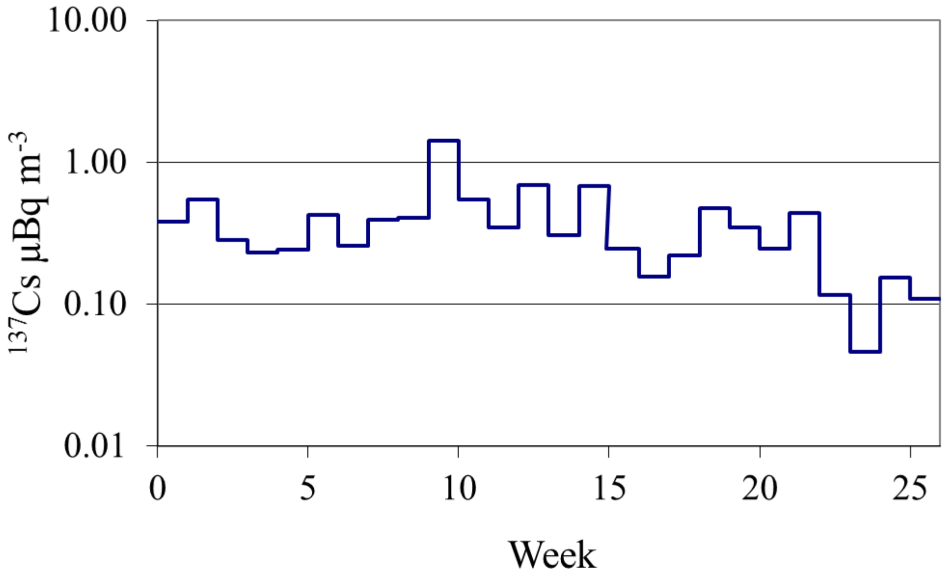

Fig. 1.1. Caesium-137 in ground level air collected at Risø in January-June 2018. (Unit: µBq m^{-3})

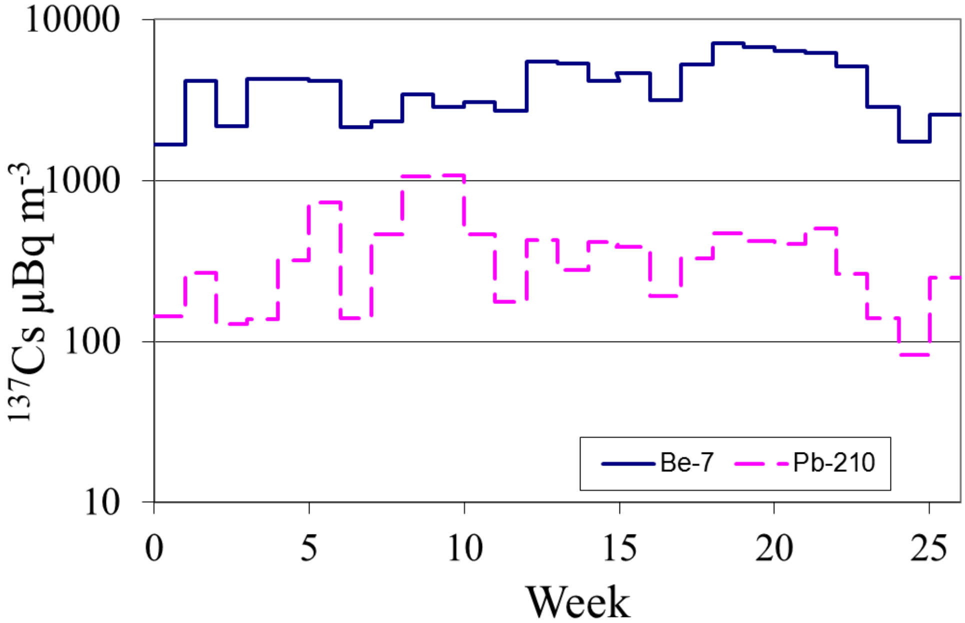

Fig. 1.2. Beryllium-7 and Lead-210 in ground level air collected at Risø in January-June 2018. (Unit: µBq m^{-3})

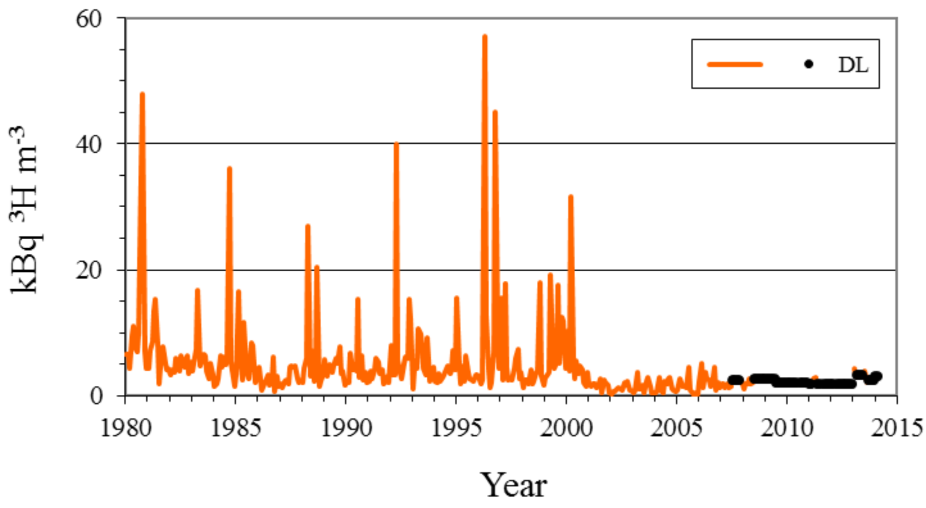

Fig. 2.3.1. Tritium in precipitation collected at Risø (1 m^2 rain collector) 1980 - 2013. (Unit: kBq m^{-3}; DL = detection limit . This rain collector was taken out of operation in 2013.

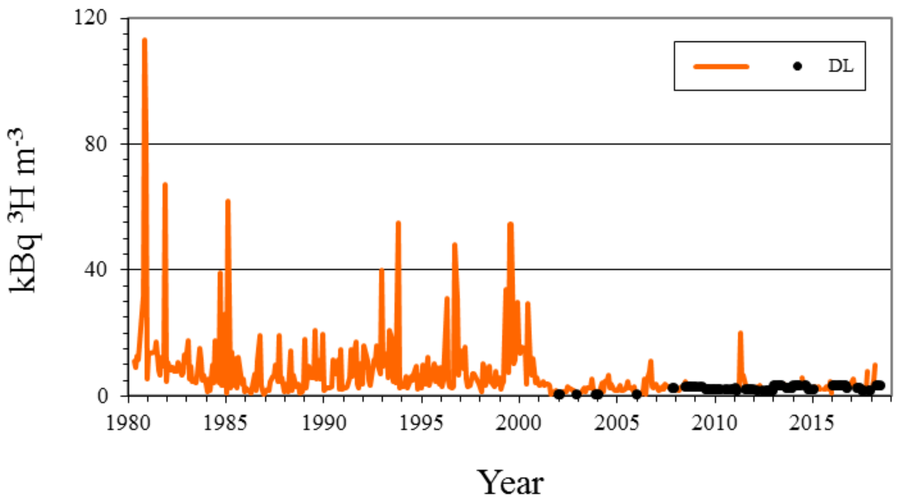

Fig. 2.3.2. Tritium in precipitation collected at Risø (10 m^2 rain collector) 1980 - 2018. (Unit: kBq m^{-3}; DL = detection limit)

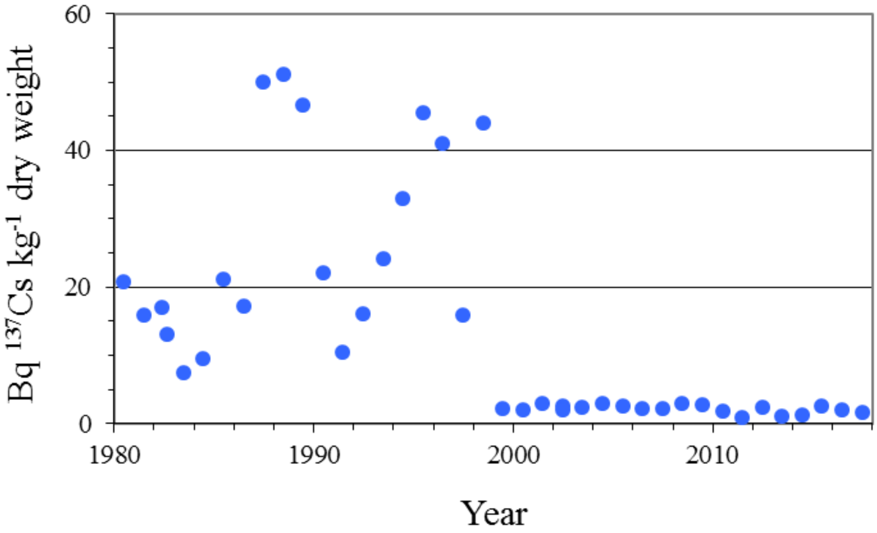

Fig. 3.1. Caesium–137 in sediment samples collected at Bolund in Roskilde Fjord. 1980 – 2018. (Unit: Bq kg^{-1} dry matter)

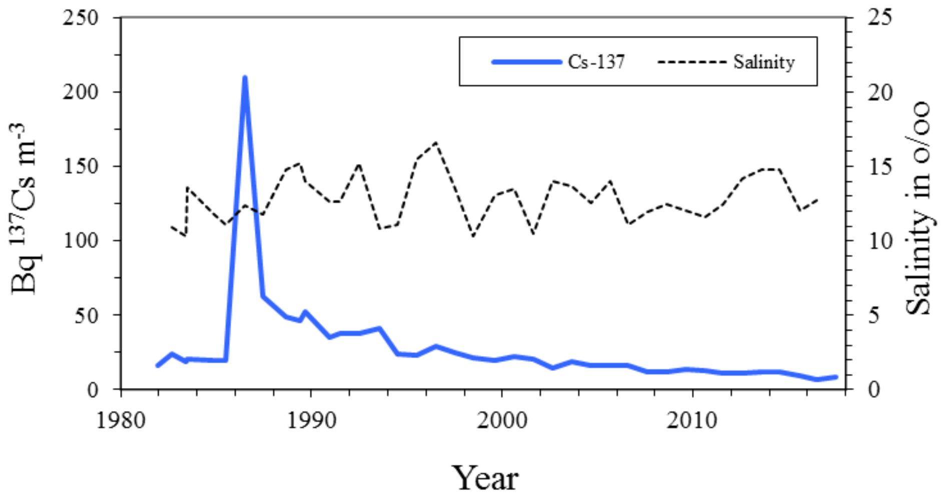

Fig. 4.1. Caesium–137 in seawater collected in Roskilde Fjord 1980 - 2018. (Unit: Bq m^{-3})

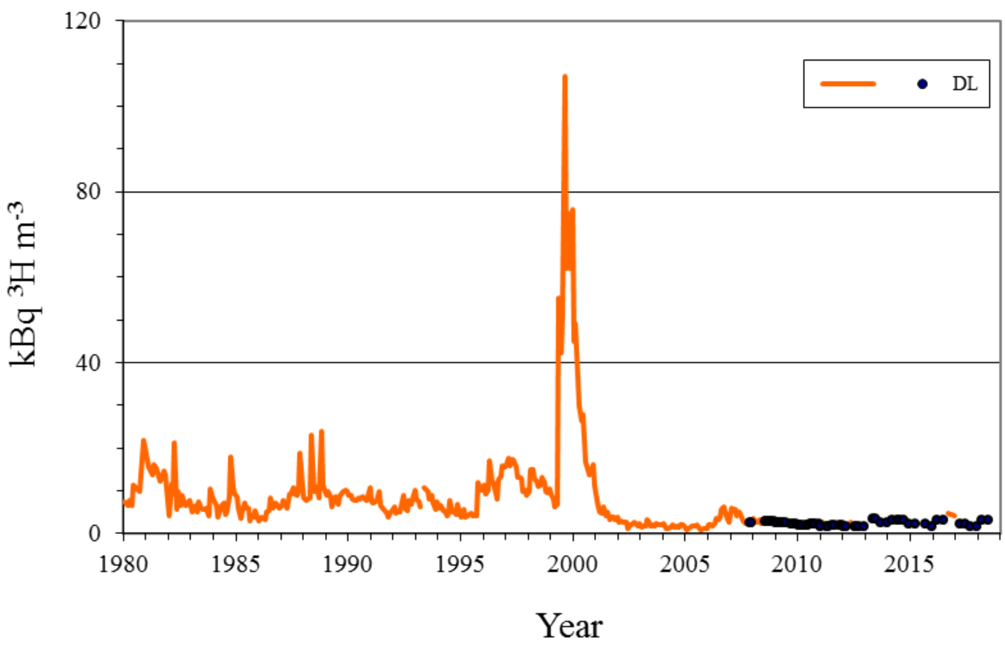

Fig. 4.2. Tritium in seawater collected in Roskilde Fjord 1980 - 2018. (Unit: kBq m^{-3}; DL = detection limit)

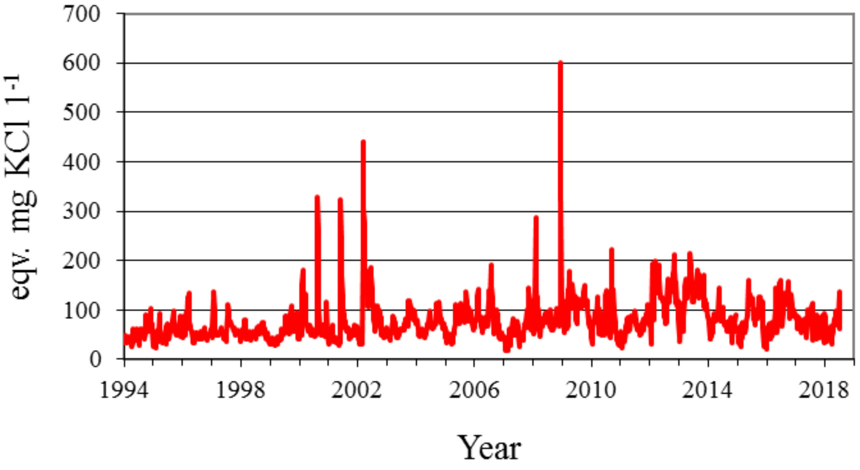

Fig. 7.1. Total-beta radioactivity in waste water collected at Risø 1994 - 2018. (Unit: eqv. mg KCl l^{-1})

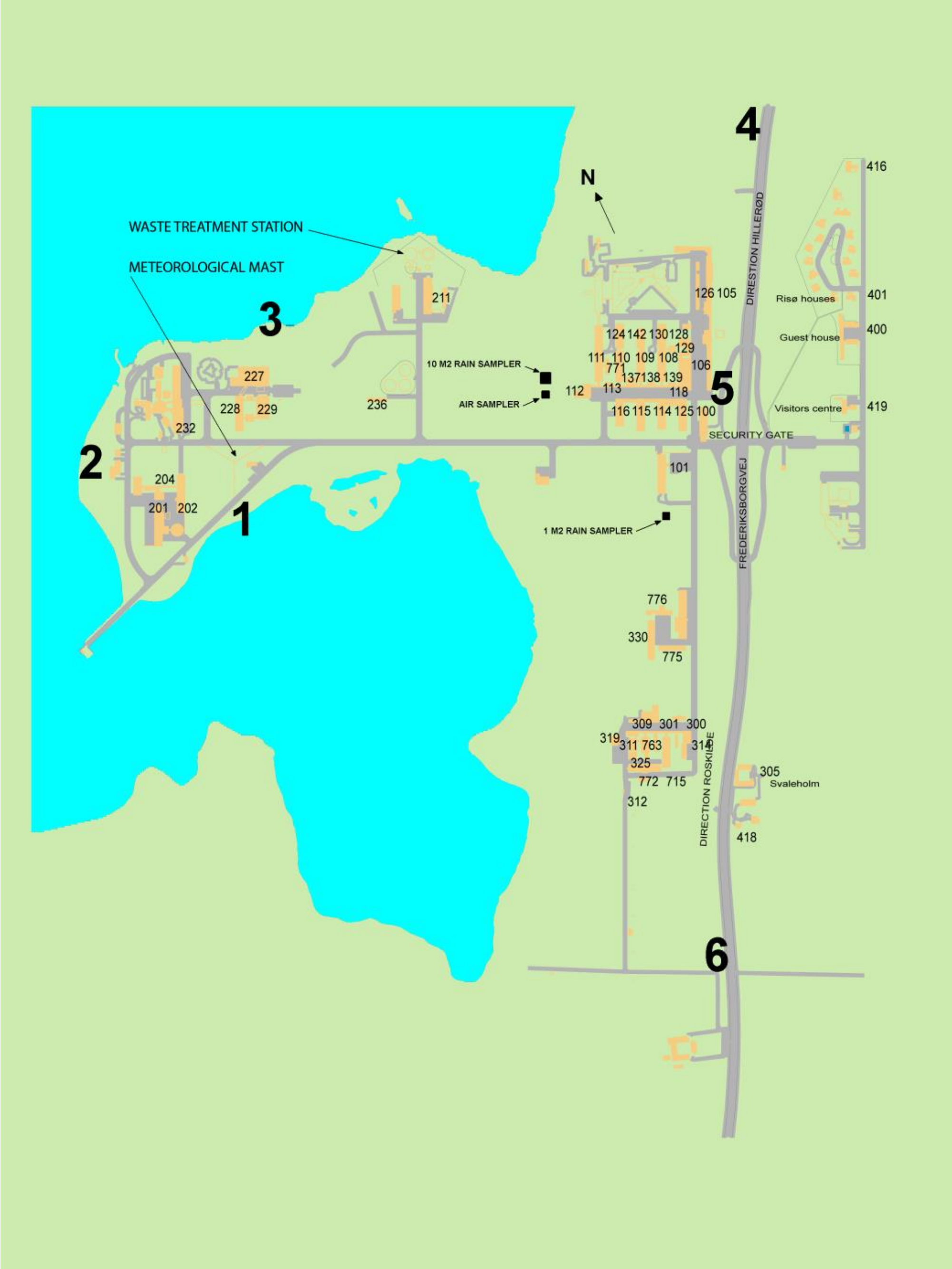

Fig. 8.1. Locations (1-6) for TLD measurements around the border of Risø (cf. Table 8.1).

Fig. 8.2. Locations for measurements of background radiation around Risø in Zones III, IV and V.

MATERIALS AND METHODS

External gamma dose rate monitoring

Monitoring of external gamma dose rate is carried out with the following devices

- Thermolumiscence dosimeters TLD: LiF, measurement frequency annually from May to April. TLD equipment manufacturer: ALNOR/RADOS
- NaI detector: 3x3 inch, SAM 935 Surveillance and Measurement System, Berkeley Nucleonics Cooperation, USA, visual read-out

Calibration of TLD is carried out by irradiation of dosimeters at a calibration irradiator. Traceability of delivered doses is ensured through calibration of the dose rate of the calibration irradiator by the National Institute of Radiation Protection (SIS). Calibration has been verified by measurement with ionisation chamber from NPL, UK. The NaI detector is calibrated periodically vs. a Reuter Stokes high-pressure ionisation chamber.

Air sampler

The sampler at Risø is manufactured by DTU. Air is drawn through a polypropylene filter at a rate of about 2000 m^3/h. The filter is normally changed weekly. The flow rate is monitored by a gas meter connected to a shunt. The gas meter reading is compared to that of a reference gas meter intermittently.

DTU analyse the filters by gamma spectrometry shortly after filter change to check for the presence of short-lived man-made radionuclides. The air filters are subsequently stored for a minimum of one week to allow for decay of short-lived naturally occurring radionuclides before repeated gamma analysis. Filters are analysed for ^{137}Cs, ^{7}Be and ^{210}Pb and other gamma emitters.

Deposition collector

The Risø site operates a large rain collector of 10 m^2. The collector is heated and water is passed through an ion exchange column to a large tank. The 10 m^2 collector provides monthly samples of rain water analysed for tritium and ion exchange resin which is analysed by gamma spectrometry for ^{7}Be, ^{137}Cs and ^{210}Pb and other gamma emitters.

Water and sediment

A waste water sample from the Waste Treatment Station is collected weekly and analysed for total beta radioactivity and the radionuclides ^{131}I, ^{137}Cs and ^{226}Ra. Water samples from Roskilde Fjord are collected each quarter and analysed for tritium, annually for ^{137}Cs. A sediment sample is collected annually from Roskilde Fjord and analysed for ^{137}Cs.

Terrestrial and aquatic biota and flora

Grass samples are collected weekly at the Risø site and analysed by gamma spectrometry. Samples are bulked to monthly samples which are analysed for ^{137}Cs.

Seaweed samples are collected annually from Roskilde Fjord at Risø and analysed for ^{137}Cs.

Sample reception and preparation

Sample identification numbers are entered in log books. Sample preparation methods include drying, freeze drying, ashing, sorting and sieving. Selected samples are archived.

Sample measurements

Radioactivity in samples is measured by total beta counting and gamma spectrometry.

Measurement devices

- Ge detectors for gamma spectrometry. Calibration of detectors is based on mixed-nuclide standards used occasionally. Monthly checks are made of detector efficiency and energy resolution. Background measurements of gamma systems are made a few times per year.
- Low-level Geiger-Müller counters for total beta counting, manufactured by DTU. Calibration based on standards of KCl. Counting efficiency and background are checked monthly.
- Liquid scintillation spectrometer for analysis of tritium in water. Samples are analysed with a calibration standard.

Analytical results, data handling and reporting tools

Analytical results are printed on paper, recorded in log books and stored in a data base on intranet. Results below detection limits recorded as such. Spreadsheets are used for calculating results from raw data.

Quality assurance, laboratory accreditation and intercomparison exercises

Analytical results are checked by experienced staff and discussed with senior scientists if questions arise.

DTU is accredited to testing for radioactivity by DANAK according to the international standard ISO 17025. The accreditation covers testing for certain non-gamma emitting radionuclides but not for radionuclides occurring in the environment and food in general.

DTU participate regularly in international intercomparisons on laboratory analyses of radionuclides.

CONCLUSIONS

This report shows the results of the environmental surveillance monitoring programme carried out at and around the Risø site in January-June 2018. The mean concentrations in air were: 0.37±0.27 μBq m^{-3} of ^{137}Cs, 4.00±1.59 mBq m^{-3} of ^{7}Be and 0.37±0.26 mBq m^{-3} of ^{210}Pb (±1 S.D.). The depositions by precipitation at Risø in the first half of 2018 were: 0.045±0.007 Bq m^{-2} of ^{137}Cs, 316±32 Bq m^{-2} of ^{7}Be, 28.4±2.6 Bq m^{-2} of ^{210}Pb and <0.9 kBq m^{-2} of ^{3}H. The average background dose rate (TLD) at Risø (Zone I) was measured as 59 nSv h^{-1} compared with 55 ± 3 nSv h^{-1} (±1 S.D.) in the four zones around Risø. None of the recorded levels of radioactivity and radiation have given rise to concern.

Center for Nuclear Technologies is Denmark's national competency center for nuclear technology. With roots in research in the peaceful use of nuclear power, DTU Nutech works with the applications of ionizing radiation and radioactive substances for the benefit of society.

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